THE MIND OF A GREENHOUSE

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2018 March, August, November | Founder of Tashi Getsen Charity School: Tsangsar Kunga ཚང་སར་ཀུ་ན་དགཔ། | principal of Tashi Getsen Charity School: Dawa Konpu ཟླ་བ་མཁན་པོ། | project founder of the greenhouse construction: Tsangsar Kunga ཚང་སར་ཀུ་ན་དགཔ།, Wiriya Rattanasuwan, site landlord: Tsangsar Metok ཚང་སར་མེ་ཏོག | local coordinators: Tsangsar Mohji ཚང་སར་མོ་སཀྱིད།

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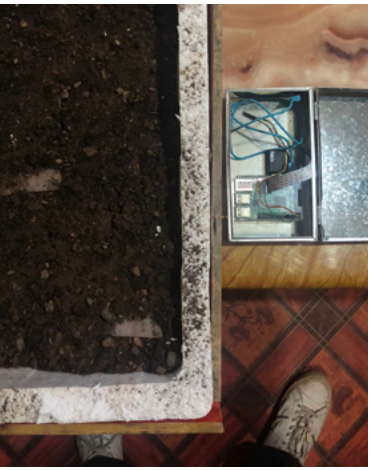

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How it started

In August to November 2018, I voluntarily participated in a charity project alongside weather engineer Wiriar Rattanansuwan and the founder of Tashi Gatsen school, Tsangsar Kunga. The initial objective of the project was to construct a greenhouse in Nangqen, Quinhai, situated at an altitude of approximately around 3,700 meters, capable of withstanding harsh winter conditions. The greenhouse aimed to provide year-round vegetables for the orphan children under the care of Tashi Gatsen School, located at 32°31′45.2″N 96°03′05.2″E. Additionally due to the over priced vegetable imported from other provinces in China. We sought to establish a connection between the charity project, art, and science, by exploring an interdisciplinary production system. Hence, constructing a greenhouse with solar cells dyed with local plants held educational and community development value.

Site location

The prototype was constructed in Tsansar Kunga's family house located in Yushu County, which is approximately a 3-hour drive from the airport. It is highly recommended to stay at this location for at least 3 days to acclimatize to the high altitude of 3,400 meters before traveling to Tashi Gatsen School, which is situated far away from medical services. Since 2018, the school has undergone a name change to Tashi Gatsen Professional School after officially receiving the school license from the Chinese government. To reach the school from Tsangsar Kunga's house, it takes an additional 5-hour car ride.

Travels and telecom service

All international flights are required to transfer from Chendu Airport (CTU). It takes approximately 5 hours to travel from Chendu to Yushu. Due to the presence of the China firewall, it is recommended to use a VPN service. Personally, I use Taiwan roaming service, which costs around 200 NTD per day, and I have not encountered any issues. However, please note that the signal is only available in Yushu County and Chendu. In 2018, there was no signal coverage within the school campus area. According to Dawa Konpu, the principal of Tashi Gatsen, the telecom service reached the school area in 2019, and now the school has 4G signal coverage.

Design of the first prototype

In the initial phase of the design, we attempted to incorporate various solutions and combine them into a single design. These solutions included the use of an earth battery, pit-house, and earth-sheltered design to create a passive solar house. The dimensions of the first prototype were 4 by 6 by 2 meters, with a depth of 2 meters. Regarding the pit-house, considering the harsh weather conditions in Nangqen county, we decided to construct our greenhouse with a depth of two meters. The roof frame was made of welded white iron and covered with transparent PC (Polycarbonate) boards, which had a multilayered structure and were sealed with silicon. Concrete bricks were utilized to build the walls around the pit, serving as support for the welded iron roof. However, we did not place bricks on the floor, nor did we provide a well-designed shelf to efficiently utilize the interior space for storing raised beds. Consequently, the local people ended up growing their plants directly on the floor, which was not an ideal outcome. It is worth noting that the interior of the house tends to be approximately 4 to 6 degrees warmer than the outdoor temperature.

In the earth battery section, we buried a PC pipe connecting the indoor and outdoor spaces of the house. This allowed us to expel the cold air and circulate it back into the house after heating it underground through an 11-meter-long tube. Inside the house, we sealed a toy fan obtained from a local vendor to the end of the tube. Our intention was to charge the fan with solar panels so that it could run overnight using the power collected during the day. However, the charger and battery were not properly set up, and the 11-meter-long tube proved to be too short to sufficiently heat the cold air. Personally, I believe this aspect can be significantly improved in the next phase. Earth battery and earth-sheltered greenhouse were the two main prototypes of our initial design. Unfortunately, there wasn't enough time to complete the earth battery component during my visit due to it being our first attempt, coupled with the difficulty of finding suitable pipes for air circulation. However, the earth-sheltered design proved effective. Upon receiving feedback from the local community after my return to Taiwan, they mentioned that they perspired inside the greenhouse and observed water dripping, indicating that the indoor temperature was above 0º. However, some individuals reported feeling dizzy and experiencing nausea after prolonged stays inside. This may be attributed to the installation of only one fan for air circulation, resulting in inadequate oxygen and an excess of CO_2.

I thought it was easy to install an raspberry pi board with a v2 camera module as simple monitor but then it took me 3 or 4 days to find a local internet cafe to install Raspian. The cafe staff became quite concerned when they saw me working with wires and codes, and I was swiftly asked to leave. Eventually, I managed to complete the installation and successfully obtain sensor data and camera vision via SSH. Regrettably, I didn't have enough time to properly install it inside the house before my flight to Taipei.

For the Roof design, initially, we considered covering the greenhouse with glass windows with aluminum frame, but ultimately we opted for transparent PC with honeycomb layers. This material is lightweight, making the construction process quicker and more cost-effective compared to using glass with aluminum frames. However, we encountered some difficulties during the roof installation due to it being divided into only 9 pieces in the design. Ideally, it should have been divided into 12 to 20 pieces to facilitate the construction process. We determined that the sun azimuth angle was approximately 79º, and accordingly, the slope of our roof was set at 23º. The greenhouse is positioned facing south, with an additional 11º counterclockwise rotation to maximize sunlight exposure.

The current status of the school

The project was concluded following the construction of the first prototype in Kunga's house. The greenhouse demonstrated potential for vegetable cultivation during spring and summer but not in winter. However, it was short-lived and quickly deteriorated due to a lack of maintenance. This experience taught us that effective management is crucial in greenhouse design, even more so than the engineering aspect.
A second greenhouse was unexpectedly built next to Tashi Gatsen School without informing us, indicating that it is a separate project from ours. I inquired about its condition with the principal upon learning of its existence. The principal Dawa Konpu clarified that it was their own design and not related to our prototype which was built in Nangqen. It was made by him and the students. The construction began on April 19th, 2020, and was completed on May 11th, 2020. Although the school now has access to the internet and public electricity, they still rely on solar cells to power the modem, resulting in unstable signal quality. Currently, the school's focus has shifted away from vegetable cultivation, and their immediate needs are a library and storage space for medicine, as per my conversation with Principal Dawa Konpu via WeChat.

計劃的起點

2018 年 8 月至 11 月間，我自願參與一項慈善計劃，與氣象工程師 Wiriar Rattanansuwan 和 Tashi Gatsen 學校創辦人 Tsangsar Kunga 一同合作。這項計劃的最初目標是在青海囊謙（海拔約 3,700 公尺）建造一座能夠耐寒過冬的溫室，為 Tashi Gatsen 學校所照顧的孤兒們全年提供蔬菜。該學校位於北緯 32°31’ 45.2”、東經 96°03’ 05.2”。此外，由於當地蔬菜需從中國其他省份運來，價格昂貴，我們希望這座溫室能作為慈善、藝術與科學的跨領域結合實踐。因此，以在地植物染色的太陽能板建造溫室，也具有教育與社區發展的價值。

溫室建造地點

原型溫室建於 Tsangsar Kunga 家中，地點位於玉樹縣，距離機場車程約三小時。建議抵達後至少在此停留三天，以適應當地 3,400 公尺的高海拔，再前往遠離醫療設施的 Tashi Gatsen 學校。自 2018 年以來，該校已正式取得辦學執照，並更名為「Tashi Gatsen 職業學校」。從 Kunga 家前往學校，尚需再搭車五小時。當地人建議第一次上來青海的人最好先在玉樹休息三天，先習慣海拔氣壓，再前往位於更高海拔的小學地點。

交通與電信

所有國際航班須經成都機場（CTU）轉機，再搭乘約五小時航程抵達玉樹。由於中國防火牆的限制，建議使用 VPN 以跨過防火牆。我使用台灣的漫遊服務，一天漫遊費約新台幣 200 元，沒有遇到任何收訊問題。不過訊號僅在玉樹與成都可用，學校所在地尚無訊號。根據校長 Dawa Konpu 表示，2019 年後校區已接通電信服務，目前可使用 4G 網路。我當時已在小學附近看到正在興建的電線桿。在小學的時候，我們必須每過幾天就開車一個小時到能收的到手機訊號的地方上網，處理email和聯絡朋友。

第一個設計

設計初期，我們嘗試將多種溫室方案整合進單一設計，包括：土壤電池、地穴式建築（pit house）、以及半地下太陽屋（earth-sheltered design）等被動式太陽能策略。考量囊謙的極寒氣候，我們選擇地穴式設計，並挖地兩米，該原型尺寸最終訂為 4×6×2 公尺。屋頂結構與梁柱材料由當地最普遍的製鐵冰箱的白鐵工廠製造。白鐵上再外覆透明 PC（聚碳酸酯）蜂巢板，以矽膠密封。地洞的四週鋪滿水泥磚堆砌的牆體以支撐屋頂。但地板未鋪磚，也沒有設計可承載育苗床的層架。當地人最終被迫直接在室內裸土面上種植作物，這並非理想狀況。儘管如此，屋內溫度推測約比室外高出 4–6°C。兩公尺深的洞的設計也已經發現不是很理想，因為這在底部造成了許多陰影。

土壤電池設計

這個設計是讓溫室外的冷空氣通過一個埋入地底下的氣管，使空氣加熱後再循環進屋內。我在當地到處打聽有無賣長管子的商店，最後在一家雜貨店的地下室找到一條長11公尺的塑膠管，口徑約10公分。管道末端安裝了來自當地市集的玩具風扇，原構想是以太陽能板白天儲電、夜間運轉。不過由於充電器與電池配置不完善，加上 11 公尺長度不足以有效加熱空氣，最後效果不彰。我認為這部分在下一階段可大幅改善。土壤電池與半地下設計原是我們的兩大核心原型，但礙於施工經驗不足與當地臨時搜尋建材物資十分困難，我無法在停留期間完成土壤電池的施工。回到台灣後，收到當地人反應，表示人在溫室內有出現流汗與看見屋頂滴水情形，間接表示溫度高於 0°C。不過也有人反映長時間待在屋內會感到頭暈、噁心，可能是因為僅有一個風扇，通風不足，導致二氧化碳在室內累積。

Raspberry Pi 與感測嘗試

原以為只需幾步驟就能安裝 Raspberry Pi 與 v2 相機模組作為簡易監控系統，結果卻花了我 3–4 天才在當地一間網咖找到能安裝 Raspbian 的環境。當網咖員工看到我連接pi到電腦上和程式視窗時顯得非常驚恐，很快就請我離開店裡。最後我還是找到另外一家願意借我電腦的商店完成了安裝，透過 SSH 連接成功讀取感測器與影像數據，但來不及將裝置正式架設到溫室內，就必須搭機返回台北。

屋頂設計

初步構想使用鋁框玻璃窗覆蓋溫室，但最後改為使用在一家雜貨店的地下室找到一條長11公尺的蜂巢式透明 PC 板，重量輕，施工速度快、成本低。然而設計上屋頂僅分割為 9 片，實際上若能分為 12 至 20 片會更利於施工，我們在安裝這些過大尺寸的PC板時吃盡了苦頭。太陽方位角約為 79°，因此我們將屋頂坡度設為 23°，朝正南方向設置，並逆時針偏轉 11°，以最大化日照角度，使溫室能收集到最多的日照能量。

學校現況

本計畫在完成 Kunga 家中的第一代原型後告一段落。該溫室在春夏季節具有蔬菜栽培潛力，但因缺乏維護，很快便損壞。這段經驗讓我明白，溫室管理甚至比工程更關鍵。後來我得知 Tashi Gatsen 學校旁邊出現另一座溫室，但並未通知我們，顯示它並非我方計畫的一部分。我詢問校長 Dawa Konpu，他表示該設施由他與學生自行設計與施工，與我方在囊謙建造的原型無關。施工時間為 2020 年 4 月 19 日至 5 月 11 日。目前學校已接通網路與市電，但仍仰賴太陽能為數據機供電，導致訊號品質不穩。根據我與校長在微信上的對話，目前學校已不再以蔬菜栽培為主要目標，反而更需要圖書館與藥品儲藏空間。

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45